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Effects of Beam Smoothing on the Hydrodynamics of Direct Drive Inertial Confinement Fusion

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ABSTRACT:

The laser uniformity requirements for the successful implementation of direct drive inertial confinement fusion are significantly different from those for indirect drive. Direct drive requires a highly uniform illumination pattern on the target in order to minimize imprinted perturbations which are then amplified by Rayleigh-Taylor growth. The various approaches to this uniformity requirement all make use of target illumination with a time varying speckle pattern. The imprint of the high spatial frequencies from speckle onto the target is ameliorated by the averaging of multiple uncorrelated speckle patterns over some effective integration time. The requirement on laser uniformity to achieve target ignition is then thought to be roughly stated in terms of requiring the aggregate normalized RMS variance of the time integrated intensity σ to be less than ~1%. However, given the complicated nature of the target physics hydrodynamics, it is clear that a more detailed analysis is necessary.

We have evaluated the hydrodynamic performance of direct drive targets in terms of the ℓ-mode spectrum imprinted as a result of a given beam smoothing method. It is shown that the choice of beam smoothing method can significantly alter this spectrum. The results of modeling of the implosion hydrodynamics at both peak velocity and ignition will be presented. It is found that low spatial frequencies (ℓ-modes of 30-100) play a dominant role at ignition and that the beam smoothing method should therefore be optimized accordingly. Two classes of beam smoothing methods (Smoothing by Spectral Dispersion -- SSD, and Induced Spatial Incoherence -- ISI) will be discussed in this context. In addition, the modeling indicates that nonlinear saturation of Rayleigh-Taylor growth plays a major role in target performance. The impact of the choice of beam smoothing method on the hydrodynamics in the nonlinear regime will also be presented.

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